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U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
915-003.4

US APPLICATION NO (If known, see 37 CFR 1 5
10/070892

INTERNATIONAL APPLICATION NO. PCT/EP99/06719	INTERNATIONAL FILING DATE September 9, 1999	PRIORITY DATE CLAIMED September 9, 1999

TITLE OF INVENTION
Determination of Data Rate, Based on Power Spectral Density Estimates

APPLICANT(S) FOR DO/EO/US
Kari Horneman, Jyrki Keisala

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371

3. [X] This is an express request to begin national examination procedures (35 U.S C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below

4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. [X] A copy of the International Application as filed (35 U.S C. 371(c)(2))

    a. [ ] is attached hereto (required only if not communicated by the International Bureau).

    b. [x] has been communicated by the International Bureau.

    c [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).

6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

    a [ ] is attached hereto.

    b [ ] has been previously submitted under 35 U.S.C. 154(d)(4).

7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S C. 371(c)(3))

    a [ ] are attached hereto (required only if not communicated by the International Bureau).

    b. [ ] have been communicated by the International Bureau.

    c [ ] have not been made; however, the time limit for making such amendments has NOT expired.

    d. [ ] have not been made and will not be made.

8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).

9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment

14. [ ] A SECOND or SUBSEQUENT preliminary amendment.

15. [ ] A substitute specification.

16. [ ] A change of power of attorney and/or address letter

17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

18. [x] A second copy of the published international application under 35 U.S.C. 154(d)(4).

19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

20. [X] Other items or information·

Express Mail No. EV 005526218 US

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/070892	PCT/EP99/06719	915-003.4

21. [x] The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

	CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	24 - 20 =	4	x $18.00	$ 72.00	
Independent claims	5 - 3 =	2	x $84.00	$ 168.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1,130.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2 +				$	
SUBTOTAL =				$ 1,130.00	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 1,130.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 1,130.00	
			Amount to be refunded:	$	
			charged:	$	

a. [x] A check in the amount of $ 1,130.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0442 . A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING: Information on this form may become public. Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

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Francis J. Maguire
NAME

31,391
REGISTRATION NUMBER

915-003.4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re Application of   :

K. Horneman et al   :

Filed: Herewith   :

For: DETERMINATION OF DATA RATE,
     BASED ON POWER SPECTRAL DENSITY ESTIMATES

Claiming priority from:

International Application PCT/EP99/06719
Filed: September 9, 1999

PRELIMINARY AMENDMENT A

Assistant Commissioner for Patents
U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir: ·

     Please preliminarily amend the above-referenced application
as follows:

IN THE SPECIFICATION:

At page 1, after line 1, please insert a new heading and text as follows:

--CROSS-REFERENCE TO RELATED APPLICATION

Priority is claimed from International Application PCT/EP99/06719, filed September 9, 1999.

IN THE CLAIMS:

Please amend the claims as follows:

3.   (Amended) A method according to claim 1, wherein the data frames are classified based on a power spectral density function estimate of the received transmission signal.

6.   (Amended) A method according to claim 3, wherein the estimation of the power spectral density function comprises the steps of:

dividing the total number of received data symbols into blocks, wherein each block includes a predefined amount of consecutive points of the signal;

calculating an individual Fourier Transform for each of said blocks for receiving squared real and imaginary points for each frequency of the signal;

calculating an individual power spectral function estimate for each of the blocks by summing the squared real and imaginary points; and

calculating the power spectral density function estimate by averaging the individual power spectral function estimates.

7.   (Amended) A method according to claim 3, wherein the power spectral density function estimate is normalised by summing the elements of the power spectral density function for obtaining

a sum of the elements and by dividing each of said elements by the sum.

8.   (Amended)   A method according to claim 1, wherein the classification further comprises a step of removing effects of noise.

9.   (Amended)   A method according to claim 8, wherein the data frames are classified based on a power spectral density function estimate of the received transmission signal, the noise removal comprising subtracting an inverse of the number of elements of the power spectral density function from the power spectral density function.

10.   (Amended)   A method according to claim 3, wherein the classification comprises further:
            calculating a variable from the power spectral density function for characterising the frequency content of the power spectral density function; and
            comparing the variable against limit values of a classification decision structure.

12.   (Amended)   A method according to claim 10, wherein the magnitude of the variable indicates the relative amount of high frequencies present in the power spectral density function.

13.   (Amended)   A method according to claim 1, wherein the communication system comprises a cellular code division multiple access communications network, and the data is transmitted between a mobile station and a base station of the network over a radio interface.

14.   (Amended)   A method according to claim 1, wherein the

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number of data transmission rate classes of the predefined classification equals the number of the possible data transmission rates.

15.   (Amended) A method according to claim 1, wherein the number of data transmission rate classes of the predefined classification is lower than the number of the possible data transmission rates.

16.   (Amended) A method for channel estimation in a cellular code division multiple access communication system wherein a plurality of data symbols is spread over a sequence of data frames in a transmission signal with variable data transmission rates, comprising:

classifying a data frame of a received transmission signal in accordance with a predefined classification of the data transmission rates; and

estimating the data transmission rate of the received data frame on basis of said classification.

18.   (Amended) A method according to claim 16, wherein a data rate information received from a transmitting station and the estimated data transmission rate are both used for the channel estimation.

21.   (Amended) Signal receiving circuitry according to claim 19, wherein the rate estimation unit is arranged to classify the received signal based on a power spectral density function estimate of the received transmission signal.

22.   (Amended) Signal receiving circuitry according to claim 19, comprising a channel estimation unit which utilises the estimated data transmission rate of the received signal in

channel estimation.

23. (Amended) A mobile station including signal receiving circuitry arranged for use in communication via a communication system with variable data transmission rates wherein data is transmitted as a plurality of data symbols over a sequence of data frames, the signal receiving circuitry comprising a rate estimation unit for receiving an incoming transmission signal, for classifying a data frame of the signal in accordance with a predefined classification of the data transmission rates, and for determining from the results of the classification an estimate of the data transmission rate of the received data frame.

24. (Amended) A base station including signal receiving circuitry for use in communication with variable data transmission rates wherein data is transmitted as a plurality of data symbols over a sequence of data frames, the signal receiving circuitry comprising a rate estimation unit for receiving an incoming transmission signal, for classifying a data frame of the signal in accordance with a predefined classification of the data transmission rates, and for determining from the results of the classification an estimate of the data transmission rate of the received data frame.

REMARKS

This preliminary amendment is submitted for the purpose of placing the application into standard U.S. format and to eliminate multiple dependencies of the claims. Approval and allowance are requested.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

3.   (Amended)   A method according to claim 1 [or 2], wherein the data frames are classified based on a power spectral density function estimate of the received transmission signal.

6.   (Amended)   A method according to [any of claims] <u>claim</u> 3 [to 5], wherein the estimation of the power spectral density function comprises the steps of:

dividing the total number of received data symbols into blocks, wherein each block includes a predefined amount of consecutive points of the signal;

calculating an individual Fourier Transform for each of said blocks for receiving squared real and imaginary points for each frequency of the signal;

calculating an individual power spectral function estimate for each of the blocks by summing the squared real and imaginary points; and

calculating the power spectral density function estimate by averaging the individual power spectral function estimates.

7.   (Amended)   A method according to [any of claims] <u>claim</u> 3 [to 6], wherein the power spectral density function estimate is normalised by summing the elements of the power spectral density function for obtaining a sum of the elements and by dividing each of said elements by the sum.

8.   (Amended)   A method according to [any of the preceding claims] <u>claim 1</u>, wherein the classification further comprises a step of removing effects of noise.

9.   (Amended)   A method according to claim 8 [when taken together with any of claims 3 to 6], <u>wherein the data frames are</u>

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classified based on a power spectral density function estimate of the received transmission signal, [wherein] the noise removal [comprises] comprising subtracting an inverse of the number of elements of the power spectral density function from the power spectral density function.

10.   (Amended) A method according to [any of claims] claim 3 [to 9], wherein the classification comprises further:
        calculating a variable from the power spectral density function for characterising the frequency content of the power spectral density function; and
        comparing the variable against limit values of a classification decision structure.

12.   (Amended) A method according to claim 10 [or 11], wherein the magnitude of the variable indicates the relative amount of high frequencies present in the power spectral density function.

13.   (Amended) A method according to [any preceding claims] claim 1, wherein the communication system comprises a cellular code division multiple access communications network, and the data is transmitted between a mobile station and a base station of the network over a radio interface.

14.   (Amended) A method according to [any preceding claims] claim 1, wherein the number of data transmission rate classes of the predefined classification equals the number of the possible data transmission rates.

15.   (Amended) A method according to [any of claims 1 to 13] claim 1, wherein the number of data transmission rate classes of the predefined classification is lower than the number of the

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possible data transmission rates.

16. (Amended) A method for channel estimation in a cellular code division multiple access communication system <u>wherein a plurality of data symbols is spread over a sequence of data frames in a transmission signal with variable data transmission rates, comprising</u> [wherein the data transmission rate is estimated in accordance with any of claims 1 to 15]<u>:</u>
<u>classifying a data frame of a received transmission signal in accordance with a predefined classification of the data transmission rates; and</u>
<u>estimating the data transmission rate of the received data frame on basis of said classification</u>.

18. (Amended) A method according to claim 16 [or 17], wherein a data rate information received from a transmitting station and the estimated data transmission rate are both used for the channel estimation.

21. (Amended) Signal receiving circuitry according to claim 19 [or 20], wherein the rate estimation unit is arranged to classify the received signal based on a power spectral density function estimate of the received transmission signal.

22. (Amended) Signal receiving circuitry according to [any of claims] <u>claim</u> 19 [to 21], comprising a channel estimation unit which utilises the estimated data transmission rate of the received signal in channel estimation.

23. (Amended) A mobile station including signal receiving circuitry <u>arranged for use in communication via a communication system with variable data transmission rates wherein data is transmitted as a plurality of data symbols over a sequence of</u>

data frames, the signal receiving circuitry comprising a rate
estimation unit for receiving an incoming transmission signal,
for classifying a data frame of the signal in accordance with a
predefined classification of the data transmission rates, and for
determining from the results of the classification an estimate of
the data transmission rate of the received data frame [according
to any of claims 19 to 22].

24. (Amended) A base station including signal receiving
circuitry for use in communication with variable data
transmission rates wherein data is transmitted as a plurality of
data symbols over a sequence of data frames, the signal receiving
circuitry comprising a rate estimation unit for receiving an
incoming transmission signal, for classifying a data frame of the
signal in accordance with a predefined classification of the data
transmission rates, and for determining from the results of the
classification an estimate of the data transmission rate of the
received data frame [according to any of claims 19 to 22].

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DETERMINATION OF DATA RATE, BASED ON POWER SPECTRAL DENSITY ESTIMATES

Field of the invention

5   The present invention relates to a method and circuitry for
estimating data rates of signals transmitted between stations
in a communication system, and more particularly, but not
explicitly, between stations in a cellular code division
multiple access (CDMA) communication system.

10

Background of the Invention

In a communication system signals can be transmitted with
variable data transmission rates wherein data is transmitted
as a plurality of data symbols in subsequent data frames. As
15   is known, in a cellular CDMA (Code Division Multiple Access)
system data is encoded for transmission by modulating data
symbols to be transmitted by a spreading code and a unique
scrambling code for each channel. Within each cell of the
cellular communication system, scrambling codes are
20   preferably as far as possible orthogonal to allow for a
plurality of different mobile stations to communicate with a
base station on selectively coded channels. The effect of a
spreading code is to spread the frequency band for
transmission to a chip rate T_c which is larger than the bit
25   rate T_b. The scrambling code is unique for each mobile station
transmitting to a single base station so that the
transmission from individual mobile stations can be
distinguished at the base station. The spreading codes are
also as orthogonal as possible within users. For example, it
30   is possible to set up such a variable-rate connection where
the data rate of the information bits, and thus the spreading
factor used in the spreading modulation of these bits, varies
from radio frame to radio frame (e.g. every 10 ms). The data

rates used in such a connection are not arbitrary, but for
each radio frame duration, one of the pre-defined data rates
is used. Moreover, every higher data rate is dividable by a
lower data rate, the division factor being 2^k for some $k \geq 0$.

5   This specification presents variable-rate connection data
rates 32, 64, 128, 256, 512, and 1024 kbps, but it is evident
that also other data rates could be used without departing
from the basic concept of the variable data rate (or
multirate) transmission.

10

When a signal is transmitted between a base station and a
mobile station (either on the uplink or the downlink) of a
CDMA system, the signal receiving unit needs to establish
from the received signal some information about the

15   communication path along which the signal has travelled.
This is referred to herein as "channel estimation" and is
usually carried out in a channel estimation unit which
generates a channel impulse response. Various techniques are
known for channel estimation. The channel impulse response is

20   required in order to properly decode and demodulate incoming
data.

The data transmission rate of the received signal can be used
in the channel estimation. However, if the data rate of a

25   received radio frame is not known at the time of the
detection at the receiver, the information symbols in said
radio frame are usually obtained by means of detecting the
complex data symbols assuming that the highest-possible data
rate is used for transmission, and using the lowest-possible

30   spreading factor in the receiving station. Assuming that the
data rate of the received radio frame was 1024 kbps, this
corresponds to the spreading factor of 4 (at 4.096 Mcps) used
in the detection of the data symbols. The result of this
detection should be a data vector of all detected complex

information symbols corresponding to the received radio
frame. Thereafter it has to be estimated what was the actual
data rate of the signal at the transmitting station during
the transmission. For example, this stage might give a
5   decision that the actual data rate in the received radio
frame was 256 kbps, not the assumed 1024 kbps. Finally, in
accordance with the estimated data rate, as many adjacent
symbols as necessary are summed together to get one actual
information symbol. In this example, this would lead to
10   summing up every four adjacent symbols to get one actual
information symbol. Therefore it would be advantageous to be
able to have the actual data rate of the transmission at the
time of the detection at the receiver circuitry.

15   The transmission between the stations may or may not include
explicit information of the data rates of the transmitted
signal. In the first case, i.e. if the variable-rate
connection includes explicit information on the used data
rates for each received radio frame, this information is
20   usually given in a separate channel, for example in an DPCCH
(Dedicated Physical Control Channel). However, this
information is often encoded in such a way that the actual
data rate of the received radio frame is not known at the
time the data symbols of the radio frame are detected. In
25   addition, it may be necessary to establish another estimate
of the data rate, for instance for the purposes of
verification and/or correction of the received data rate
information. In the latter case, i.e. if the explicit
information is not included in the received signal, so called
30   unknown or blind data rate estimation may be used at the
receiving station in order to define at the receiver the
actual data rate of the received signal.

One prior art proposal for detecting the data rate of the

received signal is based on the power difference of the
received bits in the data channel and the control channel.
This method is relatively simple as it requires only the
average power estimates of the received control symbols and

5   data symbols. However, the disadvantage of the method is that
if a very low spreading factor is used in detecting the data
symbols (4 in the above example) in the first place noise
becomes very dominant in the detection process. This degrades
substantially the performance of the data symbol power

10 estimation.

Another prior art method is based on CRC (Cyclic Redundancy
Check: an error detection signal) decoding of the received
signal. The method is based on a data rate assumption at each

15 decoding stage and a subsequent selection of a data rate
which gives a correct CRC word. To give an example, assuming
that the possible data rates are 32, 64, 128, 256, 512, and
1024 kbps, a CRC check would be calculated directly for the
information symbols of the received radio frame by assuming

20 firstly a data rate of 1024 kbps. The resulting CRC word is
stored. Two adjacent received symbols are summed together,
assuming a data rate of 512 kbps, and a further CRC check is
calculated for these information symbols. The resulting CRC
word is stored. The process continues summing two adjacent

25 information symbols together and calculating CRC checks for
all these information streams until a lowest-possible data
rate is achieved. Thereafter the stored CRC words are
verified and such a data rate is selected that corresponds
the rate used in the transmitter when a right CRC check was

30 obtained (if such existed at all). A disadvantage of this
method is that it is computationally complex: if there are N
possible data rates, this requires N consequent CRC decoding
processes before a decision of the transmitter data rate can
be made. Moreover, the method does not give any data rate if

the algorithm does not give an exactly matching CRC check.

One prior art proposal is based on metrics of Viterbi
decoding of the data, assuming (as in the CRC method) a
5   certain data rate at each stage of the decoding process. This
method, however, is also computationally complex and uses
assumptions which may lead to even more complicated
arithmetical operations and/or inaccurate results of the
estimation procedure.

10

An additional disadvantage of the two latter prior art
methods is that they delay the final decision of the data
rate of the received signal to a stage where some decoding of
the data is needed for the first time. This will make the
15   operation difficult for receiver structures that require an
estimate of the data transmission rates of the received
signals at an earlier stage than decoding. One such receiver
comprises an Interference Cancellation (IC) receiver.

20   **Summary of the Invention**

It is an aim of the embodiments of the present invention to
address one or several of the disadvantages of the prior art
data rate estimation and/or to provide a new type of solution
25   for data rate estimation.

According to an aspect of the present invention there is
provided a method for estimating data transmission rate in a
communication system with variable data transmission rates
30   wherein a transmission signal includes a plurality of data
symbols over a sequence of data frames, the method comprising
steps of classifying a data frame of a received transmission
signal in accordance with a predefined classification of the
data transmission rates and estimating the data transmission

rate of the received data frame on basis of said
classification.

According to a more specific embodiment, the classification
is based on frequency content of the received transmission
signal. The classification can be based on a power spectral
density function estimate of the received transmission
signal. The power spectral density function estimate can be
calculated using a Fast Fourier Transform algorithm and
coherent averaging of the data symbol sequence of the
received transmission signal.

The power spectral density function estimate can also be
normalised by summing the elements of the power spectral
density function for obtaining a sum of the elements and by
dividing each of said elements by the sum.

Effect of noise can be removed by subtracting an inverse of
the number of elements of the power spectral density function
from the power spectral density function.

The classification can comprise further steps of calculating
a variable from the power spectral density function for
characterising the frequency content of the power spectral
density function, and comparing the variable against limit
values of a classification decision structure.

The estimated data transmission rate can be used in channel
estimation.

According to another aspect of the present invention there is
provided a signal receiving circuitry for use in a
communication system with variable data transmission rates
wherein data is transmitted as a plurality of data symbols

over a sequence of data frames, the signal receiving
circuitry comprising a rate estimation unit for receiving an
incoming transmission signal, for classifying a data frame of
the signal in accordance with a predefined classification of
5   the data transmission rates, and for determining from the
results of the classification an estimate of the data
transmission rate of the received data frame.

According to a more specific embodiment, the signal receiving
10   circuitry is included in a mobile station and/or a base
station of a cellular communication system.

The embodiments of the present invention provide several
advantages. The embodiments of the invention can be used in a
15   situation where no rate information is transmitted. In
addition, the embodiments of the invention can be used in a
situation where the rate information is transmitted but
cannot, for reason or another, be used or detected from the
signal during the receiving process. In addition, one
20   possible use is to provide an additional data rate
information which can be used e.g. for correction or error
check of a rate information detected from the transmitted
signal. The estimate of data transmission rate can also be
used in other parts of the received signal processing
25   sequence, e.g. in an IC receiver. The possibility for an
early detection of the unknown data rate enables use of any
such receiver structure which makes use of the data rate
information at an early stage. The estimate can also be used
to assist in rate selection for Viterbi decoding of the
30   incoming data symbols, or to assist in decision of an
alternative transmission rate for decoding if an error check
fails. In addition, embodiments of the invention may assist
in provision of a system that is less sensitive to SNR
(Signal-to-Noise Ratio) fluctuation.

Brief Description of Drawings

For a better understanding of the invention and to show how
the same may be carried into effect reference will now be
made by way of example to the accompanying drawings in which:

Figure 1 is a block diagram of a mobile communication
system;

Figure 2 illustrates a reception circuitry in a station;

Figure 3 illustrates a slot structure for physical
channels for a transmission with unknown data rate;

Figure 4 illustrates a blind rate classification
algorithm according to one embodiment of the invention; and

Figure 5 is a diagram showing simulated distributions of
variables for different data rates.

Description of Preferred Embodiments of the Invention

Figure 1 is a block diagram illustrating a context in which
the present invention may be used. That is, a CDMA mobile
communication system allows a plurality of mobile stations
MS1, MS2, MS3 to communicate with a base (transceiver)
station BTS in a common cell via respective channels CH1,
CH2, CH3. These channels are distinguished from one another
by the use of scrambling codes in a manner which is know *per
se*. Figure 2 is a block diagram of a receive circuitry at a
base station in a WCDMA system (Wideband CDMA). The receive
circuitry of Figure 2 is for use in uplink direction, i.e.
for receiving signals from the mobile stations (MS). It is
noted that even though the actual receive circuitry
implementation in the downlink direction, i.e. at the mobile
station, can be somewhat different, the invention is
applicable to downlink transmissions as well.

Before describing the exemplifying receiving circuitry of
Figure 2 in more detail, a transmit circuitry (not shown)
within a transmitting station will be briefly described. Data
to be transmitted between a MS and a BTS may be speech data,
5   video data or other data. The data is encoded into a form
suitable for transmission at a bit rate T_b which is dependent
on the source of the data, as discussed above. The encoded
user data is supplied to a frame multiplexer. The user data
can also be supplied to a CRC encoder which generates a check
10   sequence (CRC) for each frame of data. Error correction
coding and bit interleaving of the frame sequence can be
accomplished prior to transmission in a manner known in the
art. The error correction is used in order to protect the
user data from errors in a radio channel so that e.g. a
15   Viterbi decoder can recover the coded data even if some of
the bits are corrupted. For error coding and decoding
purposes, tail bits defining the end of each user data
sequence can also be added to the end of user data sequence.
Bit interleaving spreads burst errors which typically occur
20   in radio channels more evenly in time to allow the decoder to
more efficiently correct the errors from the coded data.

A frame multiplexer organises the data for transmission into
a frame sequence. Figure 3 illustrates an example of a slot
25   structure for physical channels DPCCH (Dedicated Physical
Control Channel) and DPDCH (Dedicated Physical Data Channel)
in the frame sequence. The DPCCH part of the frame contains a
pilot sequence (PILOT), a possible rate information (RI)
sequence (not shown) and a transmission power control (TPC)
30   sequence. The DPDCH part of the frame contains the whole
interleaved user data sequence (user bits and possible CRC
bits and possible tail bits). Typically, the user data of the
DPDCH is divided into frame periods of 10 milliseconds each,
and each frame can have a different transmission rate. Thus,

it is possible to multiplex data from different sources into
the frame sequence for transmission and to provide different
transmission rates in different frames of the frame sequence.
In the following exemplifying embodiments the data rate
5   detection is subjected to the DPDCH sequence of the frame.

The frame sequence is supplied to a spreader which receives
spreading and scrambling codes from a code generator. The
spreading and scrambling codes are generated in accordance
10 with known CDMA techniques and will not be described further
herein. The effect of the spreading code is to spread the
frequency band for transmission to a chip rate Tc which is
larger than the bit rate T_b. As explained, the scrambling
code is unique for each mobile station transmitting to a
15 single base station so that the transmission from individual
mobile stations can be distinguished at the base station. If
M parallel code channels are employed, M data symbols are
spread using different codes and then the results are summed
together. The spread signal is supplied to a modulator which
20 modulates the signal ready for transmission, for example
according to QPSK modulation. In some systems, modulation is
carried out prior to spreading. This sequence of events,
however, has no impact on the present invention. The spread,
modulated signal is supplied to a digital to analogue (D/A)
25 converter and from there to an RF unit which supplies the
signal ready for transmission.

The reception side of the uplink connection will now be
described with reference to Figure 2. Signals incoming at an
30 antenna 30 are received by an RF unit 28 and supplied to an
analogue to digital (A/D) converter 32. It will readily be
understood that a signal may arrive at the receiving station
having experienced multipaths with differing propagation
delays dn. The A/D converter 32 supplies the digital input

signal to a synchronisation unit 34, a channel estimation
unit 37 and to each of a number of despreaders 36a, 36b, 36c.
The number of despreaders depends on the likely number of
paths experienced by the signal from the base station to the
5   mobile station and is thus dependent on the environment. The
synchronisation unit 34 handles the synchronisation of the
mobile station to the base station BTS after power has been
turned on as well as in a handover case. This includes
searching for signals which have been transmitted with the
10   unique scrambling code for that mobile station. Thus, the
synchronisation unit 34 receives the unique code from the
code generator 22. To perform the search function,
synchronisation unit utilises the unique code from the code
generator 22 and correlates it with the incoming signal until
15   a strong correlation is detected. After the synchronisation
procedure is completed, a dedicated traffic channel can be
established. An impulse response measurement unit 35 deals
with estimation of the propagation delays dn in order to be
able to provide each despreader 36a, 36b, 36c with required
20   scrambling code phases Ø. The phase value of the strongest
correlation is supplied to the first despreader 36a and the
process is continued to supply respective phase values Ø to
the remaining despreaders 36b and 36c. Respective code
generators within the despreaders 36a to 36c can thus be used
25   to despread the signal in accordance with the determined
phase difference and the resulting narrowband signals are
supplied to a coherent combiner and demodulator unit 38.

A channel phase estimate from the channel estimation unit 37
30   is needed for the combining and demodulation process of the
data symbols. Furthermore, an estimate of the data rate is
needed from a rate estimator 40 in order to be able to decide
how many successful data symbols are to be summed together.

The combined demodulated signal is supplied to a bit
detection unit (not shown) which makes a soft or hard
decision on the received symbols as to the transmitted bits.
The detected bit sequence from the bit detection unit is
5   supplied to a deinterleaving unit (not shown) which
effectively undoes the action of the interleaver of the
transmitter. The deinterleaved signal can be supplied further
to a decoder (not shown) which decodes the error correction
coded bits back to the sent user bits and possible CRC bits.
10

It is noted that several alternative circuit structures to
the embodiment shown in Figure 2 are possible to implement
the embodiments of the present invention. However, it is
generally advisable to have the rate estimation carried out
15   as soon as possible in the receiving process so that it does
not hold up the data rate estimation for longer than is
necessary.

As already briefly mentioned above, the circuit is provided
20   with the rate estimator unit 40 arranged to receive the
despread signal from the despreader 36a. The signal from
despreader 36a is assumed to be the strongest signal (i.e.
that which has come in along the primary path). As shown by
the dashed lines between the signals (branches) from the
25   despreaders 36b and 36c, it is also possible to supply
information from a plurality of the despreaders to the rate
estimator. According to an option (not shown) more than one
estimator 40 is provided in the circuitry. If a plurality of
estimators is used, each of the estimators may estimate the
30   data rate of a single signal output branch from despreaders
36a to 36c. Two or several signal branches may also be
combined prior to estimation in one of the several
estimators, e.g. such that the one estimator estimates the
strongest signal while a second estimator estimates the two

next strongest paths and so on.

The rate estimator 40 estimates the data transmission rate by examining the structure of the despread data. The following

5   will describe an embodiment for estimating the transmission data rate of subsequent frames by classifying the data rate of a received signal at the estimator 40 into one of predefined categories, whereafter the decision of the actual data rate of the received signal is based on the predefined

10   category.

The classification of the received signal can be accomplished by examining the frequency content of the received signal, e.g. by means of an estimated one-sided Power Spectral

15   Density (PSD) function of the received signal, as is shown in Figure 4. This is based on the realization that an N-point PSD function of the signal can be defined for an N-point complex time domain signal, said function providing information about the frequency content of the signal. A

20   crude estimate of the PSD function for a signal x can be calculated from a Fourier Transform (FT) of the signal x by equation:

(1) $PSD(x) = Re(FT(x)) * Re(FT(x)) + Im(FT(x)) * Im(FT(x))$

25

The PSD function includes N real values, and the relative amplitudes of these values can be translated to the relative amount of different frequencies present in the signal, starting from the frequency $f = 0$ as the first element of the

30   PSD function and spanning a frequency range up to the Nyquist critical frecuency

$$(2) \quad f_c = \frac{1}{2T_s},$$

where T_s = symbol time of one received symbol, despread by
using a spreading factor of 4. Now, as one 10 ms radio frame
5   includes 16 * 10 * 64 = 10240 such symbols, the symbol time
is:

$$T_s = 10 \text{ ms} / 10240 = 0.977 \text{ } \mu s$$

and thus $$f_c = \frac{1}{2 \cdot 0.977 \, \mu s} = 512 \text{ kHz}.$$

10

The above corresponds to a data rate of 512 kbps, which means
that in this embodiment, i.e. with a sampling rate of 0.977
μs (using a spreading factor of 4) it is not possible to
separate data rates over 512 kbps in the PSD function. This
15 is caused by the nature of the Fourier transform algorithm,
i.e. two samples for each transmitted symbol are required in
the receiver in order to be able to distinguish by a Fourier
transform a certain data rate (frequency). Since the data
rate 1024 kbps means that a spreading factor of 4 is used in
20 the transmitter, a spreading factor of 2 should then be used
in the receiver to get 2 samples of each transmitted data
symbol.

In general, having only $f_c = 512$ kHz means that in the highest
25 data rate case the frequencies over 512 kHz are *aliased* to
the PSD function, that is, they are mapped somewhere between
0 and 512 kHz. However, this does not have any
disadvantageous effect to the embodiment, since it is not
necessary to analyze directly the frequency content of the
30 signal (that is, the relative amplitudes of the PSD
function). Instead, the aim of this procedure is to interpret

the frequency content of the signal so that a single decision
variable for classification purposes is obtained. Examples of
the calculations for receiving the variable will be explained
later in this specification.

5

To estimate the PSD of the received 10240 real symbols of one
radio frame, it is possible to accomplish the estimation
procedure directly by calculating the Fourier transform of
all 10240 symbols and to subsequently calculate from the
10 Fourier transform a PSD estimate. This basic PSD method is
enough for enabling an implementation of the above method.
However, a preferred procedure discussed in the following
will yield to even better results.

15 When the total number of received symbols P = 10240, the
P symbols are divided to K blocks of N consecutive points in
each block. In this example N = 64, so $K = P / N$ = 160.
$N/2$-point FT is then calculated to each block of N real
symbols separately. Denoting $M = N / 2$ yields to M (=32)
20 complex values per each FT. The M-point real PSD function
estimate can then be calculated to each data block by summing
the squared real and imaginary points for each frequency (see
equation (1)). Finally, the final PSD function estimate is
calculated by averaging these K individual PSD function
25 estimates.

This procedure has been found to reduce the variance of the
PSD function estimate by a factor of $\sqrt{K}$ (= 12.65) from the
basic PSD method. The latter method is also in most cases
30 computationally more efficient, since the Fourier transforms
of the signal are usually calculated with some kind of Fast
Fourier transform (FFT) algorithm, and those algorithms are
generally $\log_2(N)$-complex. Thus, even though both method can

be used, it is in most cases logarithmically more efficient
to use several short FFTs than to use one long FT.

Computationally, the biggest burden of the above method lies
5   in calculating the 32-point complex Fourier transform to the
64 real symbols of a certain block. However, the complexity
of the algorithm can be significantly reduced by using a
clever FFT algorithm, preferably one that has been especially
modified to take into account certain symmetries concerning
10   the FTs of real data. Such algorithms are per se known, and
are thus not discussed in more detail herein.

In pseudo-code representation, the estimation of the PSD
function can be written now as:
15

        divide input data to K blocks, N consecutive data
        symbols in each block;
        $M = N / 2$;
        for $i := 1$ to K
20              $x :=$ all N real data symbols belonging block i;
                /* The $M = N / 2$ real points of the FFT are
                returned to fx, and the imaginary points to fy */
                FFT_REAL(x, N, fx, fy);
                for $j := 1$ to M
25                      $psd(j) := psd(j) + [fx(j)*fx(j) + fy(j)*fy(j)]$;
                end for j
        end for i
        divide all elements of $psd()$ by K;

30   After the K M-point PSD functions have been averaged to one
M-point PSD function estimate, it may be advantageous to
normalise the estimate so that the total power of the PSD
function is 1. The normalisation is done by summing all the M

elements of the *psd*() and dividing all elements by this sum. By means of this the sum of the elements of the PSD function, called as PSD *bins*, is 1.

5   When considering Additive White Gaussian Noise (AWGN) of the signal, one of its properties is that it is white, i.e. non-selective. In other words, the noise extends equally to all frequencies. From the point of view of the PSD function, this would mean that the PSD function of the AWGN would be just a

10   flat line with the value of each bin = $1/M$. For a signal of distinct frequencies of $0 \ldots f_c$ plus the AWGN noise in the signal, the PSD function would thus show a bias of $1/M$, and for the distinct frequencies the corresponding bin of the PSD function would be greater than $1/M$. Since the proposed

15   estimation method is only interested of the frequencies whose relative amount in the PSD function exceeds the noise, $1/M$ can be subtracted from the PSD function and all possible resulting negative bins can be reset to zero.

20   In pseudo-code representation, the normalisation and bias removal operations can be written as

```
NORMALISE(psd, M);
for i := 1 to M
25          psd(i) := psd(i) - 1 / M;
        if psd(i) < 0
            psd(i) := 0;
        end if
    end for i
```

30

Before the actual classification of the incoming signal, a final data rate decision variable has to be calculated. As mentioned above, the shape of the PSD function gives

information about its frequency content. It has been realized
that for a transmission of lower data rates, e.g. 32 kbps,
the PSD function of the received signal is concentrated more
to the lower bins, whereas for a transmission of higher data
rates, e.g. 1024 kbps, much higher frequencies are present in
the signal. Thus the relative amount of the higher bins
present in the PSD function has to be bigger. In order to be
able to utilize this realization, a variable characterising
the frequency content of the PSD function is calculated. A
possible variable for this is so called center-of-moment (CM)
of the PSD function:

$$(3) \qquad CM = \frac{\sum_{i=1}^{M} i \cdot psd(i)}{\sum_{i=1}^{M} psd(i)}$$

The meaning of the CM variable is as follows: the bigger the
CM, the bigger the relative amount of the higher frequencies
that are present in the PSD function, and thus it is more
probable that the transmitter bit rate was relatively high.

The above algorithm has been tested by extensive simulations
accomplished by a MATLAB simulation software provided by *The
MathWorks Inc.* The distributions of the PSD center-of-moment
variable for various transmission data rates are illustrated
in Figure 5 by a histogram in which the horizontal axis
defines the number of the PSD bins and the vertical axis
defines the number of events. The number of events axis could
also be presented in the normalised form, i.e. 0 to 1 instead
of the range from 0 to 2200. The distribution curves for
different data rates are from left to right: 32, 64, 128,
256, 512, and 1024 kbps. As can be seen from Figure 5, the
higher data or bit rates (256 and above) are very clearly

distinguished from each other, which leads to a reliable
detection of the higher bit rates.

It is possible to define the distribution of the CM variables
5   for all used (and thus possible) transmitter data rates (32,
64, 128, 256, 512, and 1024 kbps in the example). Based on
the predefined distributions, it is then possible to set
classification limits for the actual data rate decision. The
transmitter data rate estimate can thus be provided by means
10   of the CM variable calculation, followed by a classification
of the variable in accordance with a predefined
classification rules, e.g. by an estimation structure making
use of the predefined classification limits. The actual data
rate can then be defined directly from the class.
15

One possible decision structure for the final estimation is
shown below in pseudo-code representation, wherein sf =
estimate of the spreading factor used in the transmitter:

```
20        CALC_CM(psd, M, cm);
          if cm < 1.8
               sf := 128;
          else if cm >= 1.8 and cm < 2.5
               sf := 64;
25        else if cm >= 2.5 and cm < 3.7
               sf := 32;
          else if cm >= 3.7 and cm < 5.5
               sf := 16;
          else if cm >= 5.5 and cm < 8.6
30             sf := 8;
          else if cm > 8.6
               sf := 4;
          end if
```

The above structure has shown reasonable performance in the
accomplished simulations. It is noted that the above decision
limits are only tentative. In addition, the above illustrated
5   number of data transmission rate classes is only one example
of the possible number of classes. Different limit values can
be used in different embodiments, and the number of data
transmission rate classes can be freely chosen for different
implementations.
10

It is also noted that even though in a preferred embodiment
the number of the data rate classes corresponds the number of
the possible transmitter data rates, the number of the
classes does not necessarily need to correspond the number of
15   the different possible transmitter data rates. For instance,
a lower number of classes can be used such that two or
several of the lower transmitter data rates are included in
one data rate class, thereby simplifying the classification
procedure and avoiding possible problems caused by the
20   occasionally interleaving distributions of the variables for
the lower data rates. In addition, instead of using the
actual data rates, the data rate classes can also be denoted
as, for example, low, relatively low, medium, relatively
high, and high and such that some or all of the classes
25   include more than one transmitter data rate.

The accomplished simulations proved that the above embodiment
does not seem to suffer from the low signal-to-noise ratios,
as is the case in the prior art power-based method discussed
earlier in this specification. The simulations were done with
30   the E_s/N_0 = 10 dB, where the power-based method failed to
detect any data rates of the received transmission. At this
E_s/N_0 magnitude the above described embodiment, however,
achieved the following probabilities of correct data rate

detection (the simulation was accomplished for 10000 radio
frames):

Transmitter data rate [kbps]	Probability of correct data rate detection [%]
32	46.85
64	92.25
128	100
256	100
512	100
1024	100

5   When compared to the described prior art methods based on the
CRC decoding and the metrics of the Viterbi decoding, the
above embodiment has an advantage in that the data rate
estimation is not delayed to after the decoding process.
Therefore the embodiment is more suitable to e.g. different
10 Interference Cancellation methods in the receiver that the
prior art proposals. Moreover, the above described method is
less complex than the methods based on CRC or Viterbi
decoding of the data.

15 As can be seen from Figure 5 and the above table, the
described embodiment may not reliably separate in all
occasions the lowest data rates of 32 and 64 kbps from each
other. This is due the fact that every higher data rate is an
integer multiple of two of a lower data rate, the data rates
20 32 and 64 kbps being relatively close to one another. Because
of that, the distributions of the decision variable (CM) may
overlap. If the incorporation of the lower data rates into
one class is not desired and a better performance in the
separation of the lowest data rates is required (at the cost
25 of the separation of the higher data rates), the sampling
rate of the receiver could be decreased, for example, by

increasing the spreading factor from 4 to 16 in the receiver. If the length of the Fourier transform is kept the same (e.g. 64), this would lead to decrease in the critical Nyquist frequency f_c, thus improving the frequency resolution at the

5   lower frequencies while at the same time narrowing the window of the detectable frequencies. It is to be noted that this process may in some occasions lead to heavy aliasing to the frequencies higher than f_c, if they are still present in the system (i.e. there is a probability that e.g. 1024 kbps might

10   still be used in the transmitter). This aliasing effect, however, can be readily reduced by using low-pass filtering to the received signal prior to the data rate detection.

Although the invention has been described in the context of a

15   CDMA based system, it will be appreciated that similar principles can be applied in other communication systems, for example in a TDMA system or in any telecommunications device receiving data at variable rates and requiring information of the data transmission rate, such as in modems.

20

While the invention has been described above in connection with the blind data rate detection, the described data rate estimation method could be used together with rate information bits or similar data rate information in order to

25   produce verified and/or corrected data rate estimate. In this case a connection is to be provided between rate estimator unit 40 and channel estimation unit 37 or similar unit of the circuitry accomplishing the verification/correction. This is a viable alternative especially in implementations having

30   high requirements for the accuracy of the transmission rate estimation.

It is also noted herein that while the above describes exemplifying embodiments of the invention, there are several

variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention as defined in the appended claims.

24

CLAIMS

1. A method for estimating data transmission rate in a
communication system with variable data transmission rates
5   wherein a transmission signal includes a plurality of data
symbols over a sequence of data frames, comprising:
        classifying a data frame of a received transmission
signal in accordance with a predefined classification of the
data transmission rates; and
10   estimating the data transmission rate of the received
data frame on basis of said classification.

2. A method according to claim 1, wherein the data frames
are classified based on frequency content of the received
15   transmission signal.

3. A method according to claim 1 or 2, wherein the data
frames are classified based on a power spectral density
function estimate of the received transmission signal.
20

4. A method according to claim 3, wherein the power spectral
density function estimate of the received transmission signal
is calculated using a Fast Fourier Transform algorithm and
coherent averaging of the data symbol sequence of the
25   received transmission signal.

5. A method according to claim 4, wherein a modified Fast
Fourier Transform algorithm is used, said modified Fast
Fourier Transform algorithm taking predefined symmetries of
30   the transmitted data symbols into account.

6. A method according to any of claims 3 to 5, wherein the
estimation of the power spectral density function comprises
the steps of:

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dividing the total number of received data symbols into
blocks, wherein each block includes a predefined amount of
consecutive points of the signal;

calculating an individual Fourier Transform for each of
5   said blocks for receiving squared real and imaginary points
for each frequency of the signal;

calculating an individual power spectral function
estimate for each of the blocks by summing the squared real
and imaginary points; and

10   calculating the power spectral density function estimate
by averaging the individual power spectral function
estimates.

7.   A method according to any of claims 3 to 6, wherein the
15   power spectral density function estimate is normalised by
summing the elements of the power spectral density function
for obtaining a sum of the elements and by dividing each of
said elements by the sum.

20   8.   A method according to any of the preceding claims,
wherein the classification further comprises a step of
removing effects of noise.

9.   A method according to claim 8 when taken together with
25   any of claims 3 to 6, wherein the noise removal comprises
subtracting an inverse of the number of elements of the power
spectral density function from the power spectral density
function.

30   10. A method according to any of claims 3 to 9, wherein the
classification comprises further:

calculating a variable from the power spectral density
function for characterising the frequency content of the
power spectral density function; and

26

comparing the variable against limit values of a classification decision structure.

11. A method according to claim 10, wherein the variable characterising the frequency content of the received transmission signal comprises center-of-moment of the power spectral density function.

12. A method according to claim 10 or 11, wherein the magnitude of the variable indicates the relative amount of high frequencies present in the power spectral density function.

13. A method according to any preceding claims, wherein the communication system comprises a cellular code division multiple access communications network, and the data is transmitted between a mobile station and a base station of the network over a radio interface.

14. A method according to any preceding claims, wherein the number of data transmission rate classes of the predefined classification equals the number of the possible data transmission rates.

15. A method according to any of claims 1 to 13, wherein the number of data transmission rate classes of the predefined classification is lower than the number of the possible data transmission rates.

16. A method for channel estimation in a cellular code division multiple access communication system wherein the data transmission rate is estimated in accordance with any of claims 1 to 15.

17. A method according to claim 16, wherein the estimate of the data transmission rate is used to assist in rate selection for Viterbi decoding of the received data symbols.

5   18. A method according to claim 16 or 17, wherein a data rate information received from a transmitting station and the estimated data transmission rate are both used for the channel estimation.

10   19. Signal receiving circuitry for use in a communication system with variable data transmission rates wherein data is transmitted as a plurality of data symbols over a sequence of data frames, the signal receiving circuitry comprising a rate estimation unit for receiving an incoming transmission
15   signal, for classifying a data frame of the signal in accordance with a predefined classification of the data transmission rates, and for determining from the results of the classification an estimate of the data transmission rate of the received data frame.
20

20. Signal receiving circuitry according to claim 19, wherein the rate estimation unit estimates the data transmission rate based on the frequency content of the received signal.

25   21. Signal receiving circuitry according to claim 19 or 20, wherein the rate estimation unit is arranged to classify the received signal based on a power spectral density function estimate of the received transmission signal.

30   22. Signal receiving circuitry according to any of claims 19 to 21, comprising a channel estimation unit which utilises the estimated data transmission rate of the received signal in channel estimation.

23. A mobile station including signal receiving circuitry according to any of claims 19 to 22.

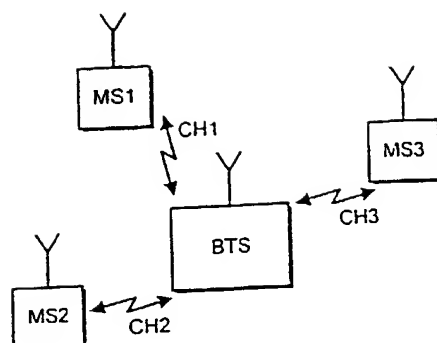24. A base station including signal receiving circuitry according to any of claims 19 to 22.

(54) Title: DETERMINATION OF DATA RATE, BASED ON POWER SPECTRAL DENSITY ESTIMATES
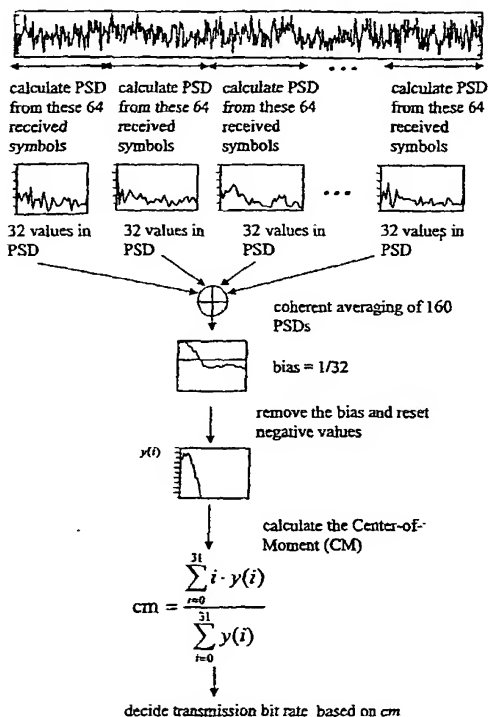
(57) Abstract: The present invention relates to a method and a circuitry for estimating data transmission rate in a communication system. The communication system utilises variable data transmission rates. A transmission signal between two stations of the system includes a plurality of data symbols over a sequence of data frames. A data frame of a received transmission signal is classified in accordance with a predefined classification of the data transmission rates, whereafter the data transmission rate of the received data frame is estimated on basis of said classification.

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Fig. 1

DPDCH	Data bits of unknown rate	

DPCCH	PILOT	TPC

Fig. 3

FIG. 2

3 / 4

calculate PSD from these 64 received symbols

calculate PSD from these 64 received symbols

calculate PSD from these 64 received symbols

calculate PSD from these 64 received symbols

32 values in PSD

32 values in PSD

32 values in PSD

32 values in PSD

coherent averaging of 160 PSDs

bias = 1/32

remove the bias and reset negative values

$y(i)$

calculate the Center-of-Moment (CM)

$$cm = \dfrac{\sum\limits_{i=0}^{31} i \cdot y(i)}{\sum\limits_{i=0}^{31} y(i)}$$

decide transmission bit rate based on *cm*

Fig. 4

Fig. 5

Distribution of PSD center of moments
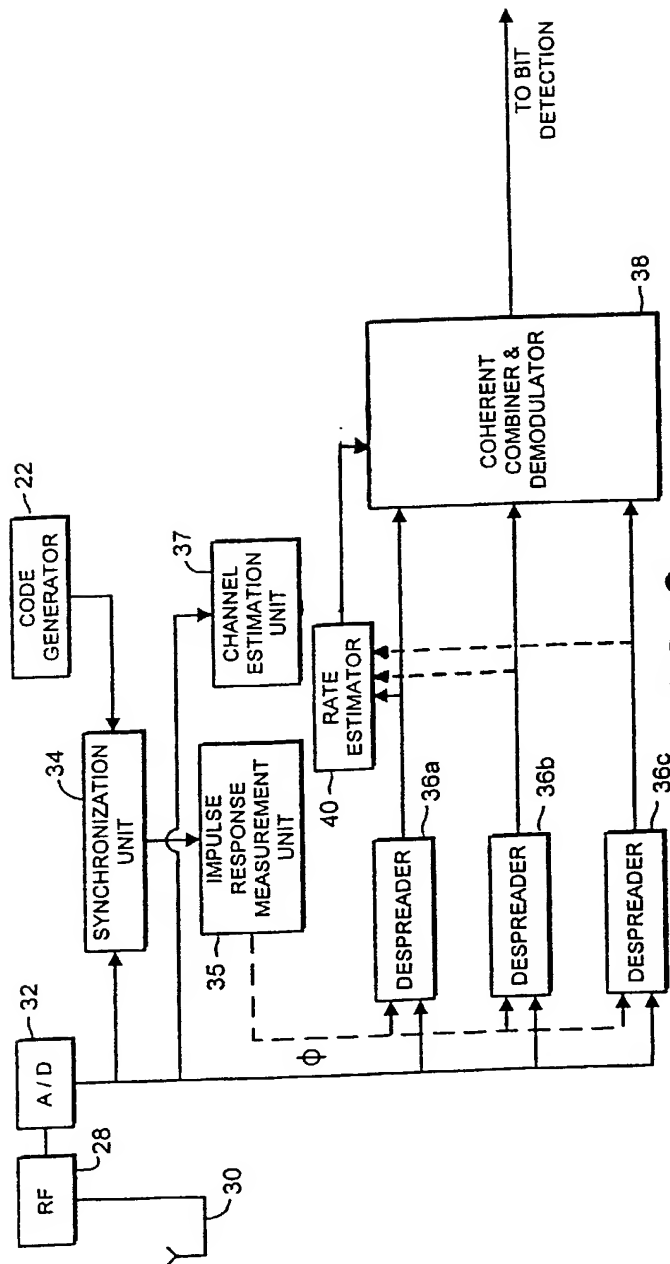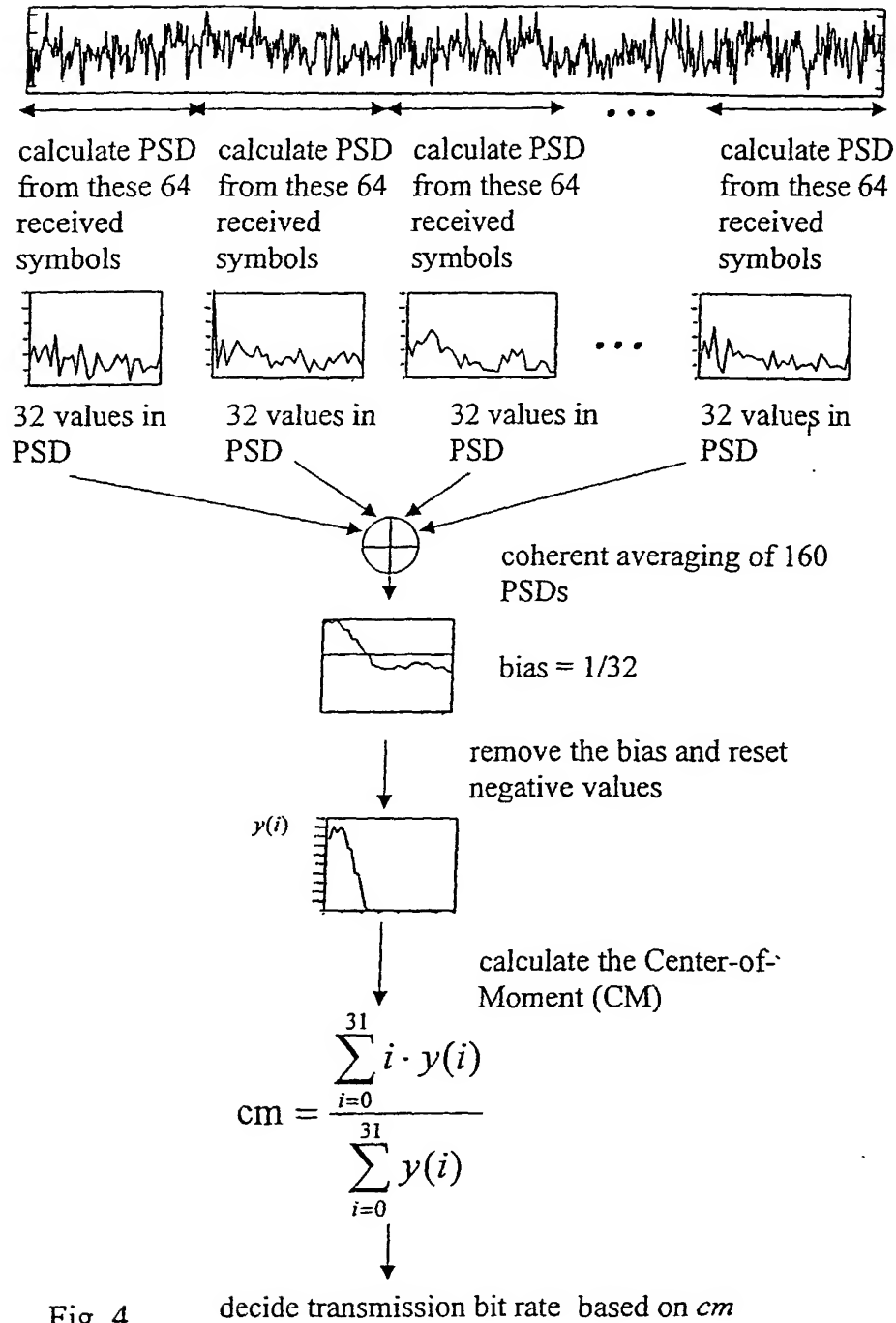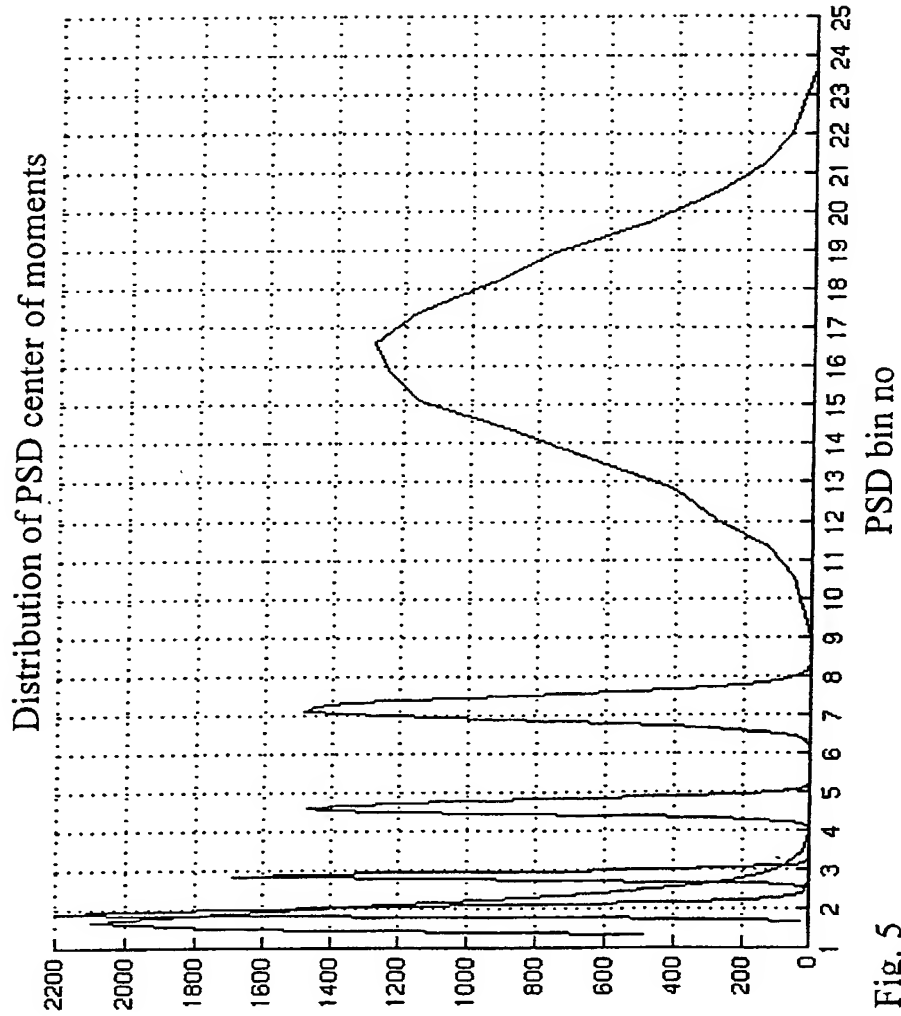
COMBINED DECLARATION AND POWER OF ATTORNEY

915-003.004
(Docket Number)

As a below named inventor, I hereby declare that:

- my residence, post office address and citizenship are as stated below next to my name;

- I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **Determination of Data Rate Based on Power Spectral Density Estimates**,

- the specification of which is attached hereto unless the following box is checked: ☒. If the box is checked,

 the application was filed on **September 9, 1999**
 as U.S. Application Number
 or PCT International Application Number **PCT/EP99/06719**
 and was amended on   (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application			Priority Not Claimed
(Application Number)	(Country)	(Day/Month/Year Filed)	☐
(Application Number)	(Country)	(Day/Month/Year Filed)	☐

To the extent permitted by rule or law, I hereby incorporate by reference the Prior Foreign Application(s) listed above.

I hereby claim the benefits under 35 U.S.C. §119(e) of any United States provisional application(s) listed below:

(Provisional Application Number)	(Day/Month/Year Filed)
(Provisional Application Number)	(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose information which is material to patentability, as defined in 37 CFR §1.56, which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Number)	(Day/Month/Year Filed)	(Status--patented, pending, abandoned)
(Application Number)	(Day/Month/Year Filed)	(Status--patented, pending, abandoned)

The undersigned hereby authorizes the U.S. firm of **Ware, Fressola, Van Der Sluys & Adolphson LLP** to accept and follow instructions from the English firm of **Page White & Farrer** as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. firm and the undersigned. In the event of a change in the persons from whom instructions may be taken, the U.S. firm will be so notified by the undersigned or his successors and assigns.

I hereby appoint the attorney(s) and/or agent(s) assigned to the customer number listed below, as may from time to time be amended, belonging to the U.S. firm of **Ware, Fressola, Van Der Sluys & Adolphson LLP**, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:
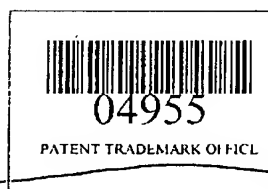
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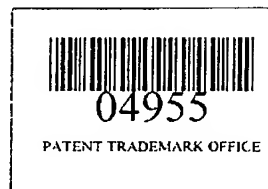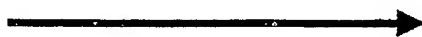
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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